CLAIMS

What is claimed is:

1. An apparatus for testing a sample for constituents comprising;

a plurality of electrochemical sensors, each sensor adapted to detect a different constituent within the sample;

a reservoir for containing the sample;

a plurality of interconnected channels fluidly coupling the reservoir to the sensors; and

a circuit coupled to the plurality of sensors to analyze the electrochemical properties of the sensors to detect the presence of a particular constituent at each sensor.

2. The apparatus of claim 1 further comprising a pump fluidly coupled to said reservoir and a plurality of interconnected channels for applying positive pressure to the reservoir and plurality of interconnected channels.

3. The apparatus of claim 2 wherein the pump is a micro-pump.

4. The apparatus of claim 2 further comprising a microheater coupled to each sensor to heat the sensor.

5. The apparatus of claim 2 wherein the circuit for detecting further determines the concentration of the constituent in the sample.

6. The apparatus of claim 1 wherein each sensor is adapted to detect a different constituent.

7. The apparatus of claim 1 wherein the electrochemical sensors each comprise an electrochemical cell comprising:

a working electrode with a coating selected to bind with a particular electro-active constituent;

a counter electrode;

a reference electrode;

filter paper disposed so as to separate between the electrodes from each other; and

an electrolyte in said filter paper.

8. The apparatus of claim 7 wherein the electrochemical cell further comprises a glass frit disposed between the channels external of the sensor and the electrodes of the sensor and a capillary housing the other elements of the sensor.

9. The apparatus of claim 7 wherein the working electrode is disposed closest to the channel through which sample enters the sensor, the counter electrode is disposed furthest from the channel through which sample enters the sensor, and the reference electrode is disposed between the other two electrodes, and wherein the capillary includes an opening disposed adjacent the working electrode through which excess sample can exit the cell.

10. The apparatus of claim 1 wherein the circuit comprises analytic circuitry for analyzing the electrochemical properties of the sensors, a multiplexer, and circuitry for controlling the multiplexer to selectively electrically couple the analytical circuitry to each of the sensors, whereby the analytical circuitry can be used to analyze each sensor distinctly.

11. The apparatus of claim 10 wherein the circuit is embodied on a single microcircuit.

12. The apparatus of claim 10 wherein the analytic circuitry is selectively

electrically coupled to the working electrode, reference electrode and counter electrode of each sensor cell and is adapted to apply a series of electrical pulses to the cell and measure the transient responses through the cell to each of the pulses.

13. The apparatus of claim 12 wherein the analytic circuitry is further adapted to integrate each current transient response to a pulse and derive electrical charge Q as a function of the magnitude of the corresponding pulse.

14. The apparatus of claim 1 wherein the channels are micro-channels.

15. The apparatus of claim 7 wherein the coating of the working electrode is adapted to bind with heme molecules.

16. The apparatus of claim 15 wherein the coating comprises dithiol.

17. The apparatus of claim 16 wherein the working electrode comprises a 25 to 100-micron-diameter, 1-meter long gold wired coiled around a 0.25 to 0.5-mm-diameter gold support wire.

18. The apparatus of claim 16 wherein the working electrode comprises a powdered gold bound together by adhesive.

19. The apparatus of claim 18 wherein the adhesive is a mixture of carbon powder and polytetraflourethylene adhesive.

20. An apparatus for testing a sample for constituents comprising;
a plurality of electrochemical sensor cells, each sensor cell adapted to detect a different constituent within the sample; and
an analytic circuitry for analyzing the electrochemical properties of the sensors;
a multiplexer; and
control circuitry for controlling the multiplexer to selectively electrically couple the analytical circuitry to each of the sensors, whereby the analytical circuitry can be used to analyze each sensor distinctly.

21. The apparatus of claim 20 wherein the analytic circuit, multiplexer and control circuit are embodied on a single microcircuit chip.

22. The apparatus of claim 21 wherein the electrochemical sensors each comprise an electrochemical cell comprising:
a working electrode with a coating selected to bind with a particular electro-active constituent;
a counter electrode;
a reference electrode;
filter paper disposed so as to separate between the electrodes from each other; and
an electrolyte in said filter paper.

23. The apparatus of claim 22 wherein the analytic circuitry is selectively electrically coupled to the working electrode, reference electrode and counter electrode of each sensor cell via the multiplexer and is adapted to apply a series of electrical pulses to the cell and measure the transient responses through the cell to each of the pulses.

24. The apparatus of claim 23 wherein the analytic circuitry is further adapted to integrate each current transient response to a pulse and derive electrical charge Q as a function of the magnitude of the corresponding pulse.

25. The apparatus of claim 24 wherein the circuit for detecting further determines the concentration of the constituent in the sample.

26. The apparatus of claim 21 further comprising a microheater coupled to each sensor cell to heat the sensor cell.

27. The apparatus of claim 20 wherein the electrochemical sensors each comprise an electrochemical cell comprising:

a working electrode with a coating selected to bind with a particular electro-active constituent;

a counter electrode;

a reference electrode;

filter paper disposed so as to separate between the electrodes from each other; and

an electrolyte in said filter paper;

wherein each working electrode has the same coating, whereby each sensor tests for the same constituent.

28. The apparatus of claim 16 wherein the working electrode comprises a 25- to 100-micron-diameter, 1-meter-long gold wired coiled around a 0.25 to 0.5-mm-diameter gold support wire.

29. The apparatus of claim 22 wherein the working electrode comprises a powdered gold bound together by adhesive.

30. The apparatus of claim 28 wherein the adhesive is a mixture of carbon powder and polytetraflourethylene adhesive.

31. A method for testing a sample for constituents comprising the steps

of:

providing a plurality of electrochemical sensors, each sensor adapted to detect a different constituent within the sample;

providing a circuit coupled to the plurality of sensors to analyze the electrochemical properties of the sensors to detect the presence of a particular constituent at each sensor;

introducing a sample into each sensor; and

simultaneously analyzing the electrical properties of each electrochemical sensor to detect the presence of at least one constituent in the sample at each sensor.

32. The method of claim 31 wherein each sample is a part of the same larger sample.

33. The method of claim 32 wherein each sensor comprises a working electrode with a coating selected to bind with a particular electro-active constituent, a counter electrode, and a reference electrode, and wherein the working electrode of each sensor has a different coating, whereby each sensor can be analyzed to detect a different constituent.

34. The method of claim 33 further comprising the steps of:

providing a reservoir for containing the sample;

providing a plurality of interconnected channels fluidly coupling the reservoir to the sensors.

35. The method of claim 34 further comprising the step of:

applying positive pressure to force the samples into the plurality of sensors.

36. The method of claim 31 wherein each sensor is adapted to detect a different constituent.

37. The method of claim 31 wherein a different sample is introduced to each sensor.

38. The method of claim 31 wherein the analyzing step further comprises the step of:

simultaneously determining the concentrations of the plurality of constituents in the sample at each sensor.

39. The method of claim 31 wherein the detecting step comprises the steps of:

selectively coupling the circuit to each sensor and analyzing each sensor sequentially.

40. The method of claim 31 wherein each sensor comprises a working electrode with a coating selected to bind with a particular electro-active constituent, a counter electrode, and a reference electrode, and wherein the detecting step comprises the steps of:

(1) selectively electrically coupling the circuit to the working electrode, reference electrode and counter electrode of one of the plurality of sensors;

(2) applying a series of electrical pulses to the cell;

(3) measuring the electrical response by the cell responsive to each of the pulses;

41. The apparatus of claim 40 wherein the detecting step further comprises the step of:

integrating each current transient response to a pulse and deriving electrical charge Q as a function of the magnitude of the corresponding pulse.